

Neha Yadav · Anupam Yadav  
Jagdish Chand Bansal · Kusum Deep  
Joong Hoon Kim *Editors*

# Harmony Search and Nature Inspired Optimization Algorithms

Theory and Applications, ICHSA 2018

Privacy Preserving Data Mining: A Review of the State of the Art ..... 1  
 Shivani Sharma and Sachin Ahuja

An MCDM-Based Approach for Selecting the Best State for Tourism in India ..... 17  
 Rashmi Rashmi, Rohit Singh, Mukesh Chand and Shwetank Avikal

Gravitational Search Algorithm: A State-of-the-Art Review ..... 27  
 Indu Bala and Anupam Yadav

Investigating the Role of Gate Operation in Real-Time Flood Control of Urban Drainage Systems ..... 39  
 Fatemeh Jafari, S. Jamshid Mousavi, Jafar Yazdi and Joong Hoon Kim

Molecular Dynamics Simulations of a Protein in Water and in Vacuum to Study the Solvent Effect ..... 49  
 Nitin Sharma and Madhvi Shakya

An Exploiting Neighboring Relationship and Utilizing an Overhearing Concept for Improvement Routing Protocol in Wireless Mesh Network ..... 57  
 Mohammad Mefteh Alrayes, Neeraj Tyagi, Rajeev Tripathi and Arun Kumar Misra

A Comparative Study of Machine Learning Algorithms for Prior Prediction of UFC Fights ..... 67  
 Hitkul, Karmanya Aggarwal, Neha Yadav and Maheshwar Dwivedy

Detection of a Real Sinusoid in Noise using Differential Evolution Algorithm ..... 77  
 Gayathri Narayanan and Dhanesh G. Kurup

xii

Contents

xiii

A Comparative Study on Feature Selection Techniques for Multi-cluster Text Data ..... 203  
 Ananya Gupta and Shahin Ara Begum

Fuzzy Decision Tree with Fuzzy Particle Swarm Optimization Clustering for Locating Users in an Indoor Environment Using Wireless Signal Strength ..... 217  
 Swathi Janjala Narayanan, Boominathan Perumal, Cyril Joe Baby and Rajen B. Bhatt

Optimization Approach for Bounds Involving Generalized Normalized  $\delta$ -Casorati Curvatures ..... 227  
 Pooja Bansal and Mohammad Hasan Shahid

Particle Swarm Optimization with Probabilistic Inertia Weight ..... 239  
 Ankit Agrawal and Sarsij Tripathi

An Evolutionary Algorithm Based Hyper-heuristic for the Job-Shop Scheduling Problem with No-Wait Constraint ..... 249  
 Sachchida Nand Chaurasia, Shyam Sundar, Donghui Jung, Ho Min Lee and Joong Hoon Kim

An Evolutionary Algorithm Based Hyper-heuristic for the Set Packing Problem ..... 259  
 Sachchida Nand Chaurasia, Donghui Jung, Ho Min Lee and Joong Hoon Kim

Developing a Decision-Making Model Using Interval-Valued Intuitionistic Fuzzy Number ..... 269  
 Syed Abou Itaf Hussain, Uttam Kumar Mandal and Sankar Prasad Mondal

A Multi-start Iterated Local Search Algorithm with Variable Degree of Perturbation for the Covering Salesman Problem ..... 279  
 Pandiri Venkatesh, Gaurav Srivastava and Alok Singh

A New Approach to Soft Hyperideals in LA-Semihypergroups ..... 293  
 Sabahat Ali Khan, M. Y. Abbasi and Aakif Fairooze Talec

Adjusted Artificial Bee Colony Algorithm for the Minimum Weight Triangulation ..... 305  
 Adis Alihodzic, Haris Smajlovic, Eva Tuba, Romana Capor Hrosik and Milan Tuba

Decision-Making Proposition of Fuzzy Information Measure with Collective Restrictions ..... 319  
 Anjali Munde

Exact Algorithm for  $L(2, 1)$  Labeling of Cartesian Product Between Complete Bipartite Graph and Cycle ..... 325  
 Sumonta Ghosh, Prosanta Sarkar and Anita Pal

Inherited Competitive Swarm Optimizer for Large-Scale Optimization Problems ..... 85  
 Prabhujit Mohapatra, Kedar Nath Das and Santanu Roy

Performance Comparison of Metaheuristic Optimization Algorithms Using Water Distribution System Design Benchmarks ..... 97  
 Ho Min Lee, Donghui Jung, Ali Sadollah, Eun Hoon Lee and Joong Hoon Kim

Comparison of Parameter-Setting-Free and Self-adaptive Harmony Search ..... 105  
 Young Hwan Choi, Sajjad Eghdami, Thi Thuy Ngo, Sachchida Nand Chaurasia and Joong Hoon Kim

Copycat Harmony Search: Considering Poor Music Player's Followership Toward Good Player ..... 113  
 Sang Hoon Jun, Young Hwan Choi, Donghui Jung and Joong Hoon Kim

Fused Image Separation with Scatter Graphical Method ..... 119  
 Mayank Satya Prakash Sharma, Ranjeet Singh Tomar, Nikhil Paliwal and Prashant Shrivastava

Ascending and Descending Order of Random Projections: Comparative Analysis of High-Dimensional Data Clustering ..... 133  
 Raghunadh Pasumuri, Vadlamudi China Venkaiah and Bhaskur Dhariyal

Speed Control of the Sensorless BLDC Motor Drive Through Different Controllers ..... 143  
 Vikas Verma, Nidhi Singh Pal and Bhavnes Kumar

Urban Drainage System Design Minimizing System Cost Constrained to Failure Depth and Duration Under Flooding Events ..... 153  
 Soon Ho Kwon, Donghui Jung and Joong Hoon Kim

Analysis of Energy Storage for Hybrid System Using FLC ..... 159  
 Ayush Kumar Singh, Aakash Kumar and Nidhi Singh Pal

Impact of Emission Trading on Optimal Bidding of Price Takers in a Competitive Energy Market ..... 171  
 Somendra P. S. Mathur, Anoop Arya and Manisha Dubey

Impact of NOVEL HVDC Superconducting Circuit Breaker on HVDC Faults ..... 181  
 Tarun Shrivastava, A. M. Shandilya and S. C. Gupta

Palmprint Matching based on Normalized Correlation Coefficient and Mean Structural Similarity Index Measure ..... 193  
 Deval Verma, Himanshu Agarwal and A. K. Aggarwal

xiv

Contents

The Forgotten Topological Index of Graphs Based on New Operations Related to the Join of Graphs ..... 335  
 Prosanta Sarkar, Nilanjan De and Anita Pal

Clustering and Auction in Sequence: A Two Fold Mechanism for Participatory Sensing ..... 347  
 Jaya Mukhopadhyay, Vikash Kumar Singh, Sajal Mukhopadhyay and Anita Pal

High-Order Compact Finite Difference Scheme for Euler-Bernoulli Beam Equation ..... 357  
 Maheshwar Pathak and Pratibha Joshi

Test Case Optimization and Prioritization Based on Multi-objective Genetic Algorithm ..... 371  
 Deepthi Bala Mishra, Rajashree Mishra, Arup Abhinna Acharya and Kedar Nath Das

PSO-SVM Approach in the Prediction of Scour Depth Around Different Shapes of Bridge Pier in Live Bed Scour Condition ..... 383  
 B. M. Sreedhara, Geetha Kuntoji, Mani and S. Mandal

Replenishment Policy for Deteriorating Items Under Price Discount ..... 393  
 Anubhav Namdeo and Uttam Kumar Khedtekar

Performance Emission Characterization of a LPG-Diesel Dual Fuel Operation: A Gene Expression Programming Approach ..... 405  
 Amitav Chakraborty, Sumit Roy and Rahul Banerjee

Comprehensive Survey of OLAP Models ..... 415  
 Harkiran Kaur and Gursimran Kaur

Energy Efficiency in Load Balancing of Nodes Using Soft Computing Approach in WBAN ..... 423  
 Rakhee and M. B. Srinivas

Single Image Defogging Based on Local Extrema and Relativity of Gaussian ..... 431  
 R. Vignesh and Philomina Simon

Improved Edge-Preserving Decomposition Based on Single Image Dehazing ..... 441  
 S. K. Anusuman and Philomina Simon

Global and Local Neighborhood Based Particle Swarm Optimization ..... 449  
 Shakti Chourasia, Harish Sharma, Manoj Singh and Jagdish Chand Bansal

|  |  |
|--|--|
| <b>Rough Set Theoretic and Logical Study of Some Approximation Pairs Due to Pomykala</b> ..... 461                                   |  |
| Pulak Sarmata  |  |
| <b>The Benefits of Carrier Collaboration for Capacity Shortage Under Incomplete Advance Demand Information</b> ..... 471             |  |
| Arindam Debroy and S. P. Sarmah  |  |
| <b>Allocation of Bins in Urban Solid Waste Logistics System</b> ..... 485  |  |
| P. Rathore and S. P. Sarmah  |  |
| <b>Image Segmentation Through Fuzzy Clustering: A Survey</b> ..... 497   |  |
| Rashi Jain and Rama Shankar Sharma   |  |
| <b>Study of Various Technologies in Solar Power Generation</b> ..... 509   |  |
| Siddharth Gupta, Pratibha Tiwari and Komal Singh   |  |
| <b>Reduction of Test Data Volume Using DTESFF-Based Partial Enhanced Scan Method</b> ..... 521                                       |  |
| Ashok Kumar Subag  |  |
| <b>Performance Analysis and Optimization of Vapour Absorption Refrigeration System Using Different Working Fluid Pairs</b> ..... 527 |  |
| Paras Kalra, Sushem Kashyap, Vishal Sharma, Geetanjali Raghav and Jasmeet Kalra  |  |
| <b>Vehicle Routing Problem with Time Windows Using Meta-Heuristic Algorithms: A Survey</b> ..... 539                                 |  |
| Aditya Dixit, Apoorva Mishra and Anupam Shukla   |  |
| <b>Design and Aerodynamic Enhancement of Wing for BMW 5 Series Model</b> ..... 547   |  |
| A. Agrawal, A. Juneja, A. Gupta, R. Mathur and G. Raghav   |  |
| <b>Semi-distributed Modelling of Stormwater Drains Using Integrated Hydrodynamic EPA-SWM Model</b> ..... 557                         |  |
| M. K. Sinha, K. Baier, R. Azzam, T. Baghel and M. K. Verma   |  |
| <b>A MCDM-Based Approach for Selection of a Sedan Car from Indian Car Market</b> ..... 569   |  |
| Rohit Singh, Rashmi and Shwetank Avikal  |  |
| <b>Design and Simulation of Photovoltaic Cell Using Simscape MATLAB</b> ..... 579  |  |
| Sucheta Singh, Shubhra Aakanksha, Manisha Rajoriya and Mohit Sahni   |  |
| <b>A Regulated Computer Cooling Method: An Eco-Friendly Approach</b> ..... 589   |  |
| Kumar Gourab Mallik and Sunita Kumar Guha  |  |

|  |  |
|--|--|
| <b>Applying PSO Based Technique for Analysis of Geffe Generator Cryptosystem</b> ..... 741   |  |
| Maiya Din, Saibal K. Pal and S. K. Muttoo  |  |
| <b>An Agent-Based Simulation Modeling Approach for Dynamic Job-Shop Manufacturing System</b> ..... 751   |  |
| Om Ji Shukla, Gunjan Soni, Rajesh Kumar, A. Sujil and Surya Prakash  |  |
| <b>Risk Analysis of Water Treatment Plant Using Fuzzy-Integrated Approach</b> ..... 761  |  |
| Priyank Srivastava, Mohit Agrawal, G. Aditya Narayanan, Manik Tandon, Mridul Narayan Tulsian and Dinesh Khanduja   |  |
| <b>Keyframes and Shot Boundaries: The Attributes of Scene Segmentation and Classification</b> ..... 771  |  |
| N. Kumar and N. Sukavanam  |  |
| <b>Toward Human-Powered Lower Limb Exoskeletons: A Review</b> ..... 783  |  |
| Ashish Singla, Saurav Dhand, Ashwin Dhawad and Gurvinder S. Virk   |  |
| <b>An Efficient Bi-Level Discrete PSO Variant for Multiple Sequence Alignment</b> ..... 797  |  |
| Soniya Lalwani, Harish Sharma, M. Krishna Mohan and Kusum Deep   |  |
| <b>System Identification of an Inverted Pendulum Using Adaptive Neural Fuzzy Inference System</b> ..... 809  |  |
| Ishan Chawla and Ashish Singla   |  |
| <b>Dynamic Modeling of Flexible Robotic Manipulators</b> ..... 819   |  |
| Ashish Singla and Amardeep Singh   |  |
| <b>Academic Performance Prediction Using Data Mining Techniques: Identification of Influential Factors Effecting the Academic Performance in Undergrad Professional Course</b> ..... 835 |  |
| Preet Kamal and Sachin Ahuja   |  |
| <b>An Area IF-Defuzzification Technique and Intuitionistic Fuzzy Reliability Assessment of Nuclear Basic Events of Fault Tree Analysis</b> ..... 845                                     |  |
| Mohit Kumar  |  |
| <b>Spotted Hyena Optimizer for Solving Complex and Non-linear Constrained Engineering Problems</b> ..... 857   |  |
| Gaurav Dhiman and Vijay Kumar  |  |
| <b>Reconfiguration of PTZ Camera Network with Minimum Resolution</b> ..... 869   |  |

|   |  |
|---|--|
| <b>Robust Control Techniques for Master-Slave Surgical Robot Manipulator</b> ..... 599  |  |
| Mohd Salim Qureshi, Gopi Nath Kaki, Pankaj Swamkar and Sushma Gupta   |  |
| <b>OLAP Approach to Visualizations and Digital ATLAS for NRIs Directory Database</b> ..... 611  |  |
| Harkiran Kaur, Kawaljeet Singh and Tejinder Kaur  |  |
| <b>Problems Associated with Hydraulic Turbines</b> ..... 621  |  |
| Aman Kumar, Kunal Govil, Gaurav Dwivedi and Mayank Chhabra  |  |
| <b>A Sine-Cosine Optimizer-Based Gamma Corrected Adaptive Fractional Differential Masking for Satellite Image Enhancement</b> ..... 633 |  |
| Himanshu Singh, Anil Kumar and L. K. Balyan   |  |
| <b>Electrical Conductivity Sensing for Precision Agriculture: A Review</b> ..... 647  |  |
| Sonia Gupta, Mohit Kumar and Rashmi Priyadarshini   |  |
| <b>Spam Detection Using Ensemble Learning</b> ..... 661   |  |
| Vashu Gupta, Aman Mehta, Akshay Goel, Utkarsh Dixit and Avinash Chandra Pandey  |  |
| <b>A Coupled Approach for Solving a Class of Singular Initial Value Problems of Lane-Emden Type Arising in Astrophysics</b> ..... 669   |  |
| Pratibha Joshi and Maheshwar Pathak   |  |
| <b>Identification of Hindi Plain Text Using Artificial Neural Network</b> ..... 679   |  |
| Siddheshwar Mukhede, Amol Prakash and Maiya Din   |  |
| <b>A Variable Dimension Optimization Approach for Text Summarization</b> ..... 687  |  |
| Pradeepika Verma and Hari Om  |  |
| <b>Minimizing Unbalance of Flexible Manufacturing System by Genetic Algorithm</b> ..... 697   |  |
| Kritika Gaur, Indu and Vivek Chawla   |  |
| <b>"Big" Data Management in Cloud Computing Environment</b> ..... 707   |  |
| Mohit Agarwal and Gur Manoj Saran Srivastava  |  |
| <b>Automatic Optimization of Test Path Using Firefly Algorithm</b> ..... 717  |  |
| Nisha Rathee, Rajendra Singh Chhillar, Sakshi Vij and Sakshi Kukreja  |  |
| <b>Image Denoising Techniques: A Brief Survey</b> ..... 731   |  |
| Lokesh Singh and Rekhram Janghel  |  |

|  |  |
|--|--|
| <b>Performance Evaluation of Optimization Techniques with Vector Quantization Used for Image Compression</b> ..... 879 |  |
| Rausheen Bal, Aditya Bakshi and Sunanda Gupta  |  |
| <b>Single Multiplicative Neuron Model in Reinforcement Learning</b> ..... 889  |  |
| Shobhit Nigam  |  |
| <b>Analysis of Educational Data Mining</b> ..... 897   |  |
| Ravinder Abuja, Animesh Jha, Rahul Maurya and Rishabh Srivastava   |  |
| <b>A Review on Search-Based Tools and Techniques to Identify Bad Code Smells in Object-Oriented Systems</b> ..... 909  |  |
| Anandeep Kaur and Gaurav Dhiman  |  |
| <b>Feature Selection Using Metaheuristic Algorithms on Medical Datasets</b> ..... 923                                  |  |
| Shivam Mahendra and Shushank Agarwal   |  |
| <b>Improved Mutation-Based Particle Swarm Optimization for Load Balancing in Cloud Data Centers</b> ..... 939          |  |
| Neha Sethi, Surjit Singh and Gurvinder Singh   |  |
| <b>Computational Intelligence Tools for Protein Modeling</b> ..... 949   |  |
| Rajesh Kondabala and Vijay Kumar   |  |
| <b>Performance Analysis of Space Time Trellis Codes in Rayleigh Fading Channel</b> ..... 957                           |  |
| Shakti Raj Chopra, Akhil Gupta and Himanshu Monga  |  |
| <b>Neural Network Based Analysis of Lightweight Block Cipher PRESENT</b> ..... 969                                     |  |
| Girish Mishra, S. V. S. N. V. G. Krishna Murthy and S. K. Pal  |  |
| <b>User Profile Matching and Identification Using TLBO and Clustering Approach Over Social Networks</b> ..... 979      |  |
| Shruti Garg, Sandeep K. Raghuvanshi and Param Deep Singh   |  |
| <b>Hybrid Metaheuristic Based Scheduling with Job Duplication for Cloud Data Centers</b> ..... 989                     |  |
| Rachhpal Singh   |  |
| <b>Total Fuzzy Agility Evaluation Using Fuzzy Methodology: A Case Study</b> ..... 999                                  |  |
| Priyank Srivastava, Dimesh Khanduja, Vishnu P. Agrawal and Neeraj Saini  |  |
| <b>Black-Hole Gbest Differential Evolution Algorithm for Solving Robot Path Planning Problem</b> ..... 1009            |  |
| Prashant Sharma, Harish Sharma, Sandeep Kumar and Kavita Sharma  |  |

|  |      |
|--|------|
| <b>Fibonacci Series-Inspired Local Search in Artificial Bee Colony Algorithm</b> .....                                 | 1023 |
| Nirmala Sharma, Harish Sharma, Ajay Sharma and Jagdish Chand Bansal  |      |
| <b>Analysis of Lightweight Block Cipher FeW on the Basis of Neural Network</b> .....                                   | 1041 |
| Aayush Jain and Girish Mishra  |      |
| <b>Analysis of RC4 Crypts Using PSO Based Swarm Technique</b> .....  | 1049 |
| Maiya Din, Saibal K. Pal and S. K. Munoo   |      |
| <b>Pipe Size Design Optimization of Water Distribution Networks Using Water Cycle Algorithm</b> .....                  | 1057 |
| P. Praneeth, A. Vasani and K. Srinivasa Raju   |      |
| <b>An Improved Authentication and Data Security Approach Over Cloud Environment</b> .....                              | 1069 |
| Ranjay Dangi and Satish Pawar  |      |
| <b>Second Derivative-Free Two-Step Extrapolated Newton's Method</b> .....  | 1077 |
| V. B. Kumar Vatti, Ramadevi Sri and M. S. Kumar Mylapalli  |      |
| <b>Review of Deep Learning Techniques for Gender Classification in Images</b> .....                                    | 1089 |
| Neelam Dwivedi and Dushyant Kumar Singh  |      |
| <b>A Teaching-Learning-Based Optimization Algorithm for the Resource-Constrained Project Scheduling Problem</b> .....  | 1101 |
| Dheeraj Joshi, M. L. Mittal and Manish Kumar   |      |
| <b>A Tabu Search Algorithm for Simultaneous Selection and Scheduling of Projects</b> .....                             | 1111 |
| Manish Kumar, M. L. Mittal, Gunjan Soni and Dheeraj Joshi  |      |
| <b>A Survey: Image Segmentation Techniques</b> .....   | 1123 |
| Gurbaksh Phonsa and K. Manu  |      |
| <b>Analysis and Simulation of the Continuous Stirred Tank Reactor System Using Genetic Algorithm</b> .....             | 1141 |
| Harsh Goud and Pankaj Swarnkar   |      |
| <b>Fuzzy Logic Controlled Variable Frequency Drives</b> .....  | 1153 |
| Kartik Sharma, Anubhav Agrawal and Shuvabrata Bandopadhyaya  |      |
| <b>Butterfly-Fat-Tree Topology-Based Fault-Tolerant Network-on-Chip Design Using Particle Swarm Optimization</b> ..... | 1165 |
| P. Veda Bhanu, Pranav Venkatesh Kulkarni, U. Anil Kumar and J. Soumya  |      |

|  |      |
|--|------|
| <b>Big Data Classification Using Scale-Free Binary Particle Swarm Optimization</b> .....                           | 1177 |
| Sonu Lal Gupta, Anurag Singh Baghel and Asif Iqbal   |      |
| <b>Face Recognition: Novel Comparison of Various Feature Extraction Techniques</b> .....                           | 1189 |
| Yashoda Mukhija and Rama Shankar Sharma  |      |
| <b>Performance Analysis of Hidden Terminal Problem in VANET for Safe Transportation System</b> .....               | 1199 |
| Ranjeet Singh Tomar, Mayank Satya Prakash Sharma, Sudhanshu Jha and Brijesh Kumar Chaurasia                        |      |
| <b>Effect of Various Distance Classifiers on the Performance of Bat and CS-Based Face Recognition System</b> ..... | 1209 |
| Preeti and Dinesh Kumar  |      |
| <b>An Improved TLBO Leveraging Group and Experience Learning Concepts for Global Functions</b> .....               | 1221 |
| Jainder Kaur, Surjeet Singh Chauhan and Pavitdeep Singh  |      |
| <b>Author Index</b> .....  | 1235 |

# A Teaching–Learning-Based Optimization Algorithm for the Resource-Constrained Project Scheduling Problem



Dheeraj Joshi, M. L. Mittal and Manish Kumar

**Abstract** In this paper, a recently introduced population-based metaheuristic known as teaching–learning-based optimization algorithm (TLBO) is used to find solution for the resource-constrained project scheduling problem (RCPSP). The RCPSP is considered in its basic form, wherein activities are non-preemptive in nature and their execution is possible in a single mode only. The scheduling objective chosen is minimizing the makespan or total project duration. TLBO algorithm in its original form employs two phases, namely the teacher phase and the learner phase to reach a global optimum solution. In order to increase the exploitation and exploration capabilities of the basic TLBO the concepts of elitism and mutation as used in genetic algorithm (GA) have been introduced. An activity list representation is used to represent a learner (solution) and to derive the schedule from this activity list a serial schedule generation scheme is used as a decoding procedure. It has been found after the computational experiment on a test problem from the literature that proposed TLBO gives results competitive to the other metaheuristics like GA and particle swarm optimization (PSO). In addition, it offers the inherent advantage of less parameter to tune and can, therefore, be used as an effective method to solve RCPSP and its other variants as well.

**Keywords** Resource-constrained project scheduling · Metaheuristic Teaching–learning-based optimization

---

D. Joshi (✉)

Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur, India  
e-mail: dheerajjoshi25@gmail.com

D. Joshi · M. L. Mittal · M. Kumar

Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur 302017, India

© Springer Nature Singapore Pte Ltd. 2019

N. Yadav et al. (eds.), *Harmony Search and Nature Inspired Optimization Algorithms*, Advances in Intelligent Systems and Computing 741,  
[https://doi.org/10.1007/978-981-13-0761-4\\_103](https://doi.org/10.1007/978-981-13-0761-4_103)

1101